

Name: _____

Chemistry 129.01 Spring 2012

General Chemistry

Midterm Examination:

Equations, constants and periodic table are provided.

You may use a calculator.

Show all your work!

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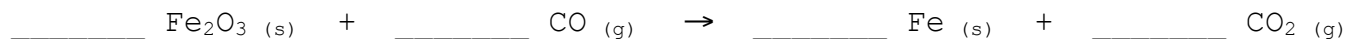
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Bonus: _____/2

Total: _____/150

1. (24 pts.) Consider the reaction of 107 g of Fe_2O_3 with 85.8 g of CO to produce Fe and CO_2 :

a) Balance the chemical equation for this reaction. (2 pts.)



b) Determine the oxidation number of each element (in each reactant and product). Which element is reduced and which oxidized? Which are the oxidizing agent and reducing agent? (9 pts.)

Reactants		Products	
Element	Oxidation	Element	Oxidation Number
Fe		Fe	
O (in		C	
C		O	
O (in CO)			

c) Find the limiting reactant and the amount of Fe produced in **grams**. (10 pts.)

d) If 15.3 g of Fe_3 are collected, what is the percent yield of the reaction? (3 pts.)

2. (10 pts) Caffeine contains 49.5% C, 5.15% H, 28.9% N, and 16.5% O and has a molar mass of 195g/mol. Find its empirical and molecular formulas.

3. (8 pts.) Fill in the gaps in the following table. Each column may represent a neutral atom or an ion.

Symbol	${}_{13}^{27}\text{Al}^{3+}$	
Protons		
Neutrons		54
Electrons		
Mass Number		96
Charge		0

4. (10 pts) The energy of an orbit in the hydrogen atom is:

$$E_n = -2.18 \times 10^{-18} J \left(\frac{1}{n^2} \right) \quad \text{where } n = 1, 2, 3, \dots$$

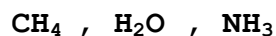
(a) For an electron transition in the hydrogen atom from $n=2$ to $n=3$, what is the associated change in energy? Does this transition correspond to absorption or emission of energy? (5 pts.)

(b) What is the wavelength of light this energy change corresponds to? What type of electromagnetic radiation is this? (5 pts.)

5. (8 pts.) Fill in the gaps in the following table.

Name	Formula	Ionic or Covalent?
copper (II) sulfate		
	N_2O_4	
	$FeCl_3$	
phosphorus trichloride		

6. (5 pts.) Predict which of the following molecules would have bond angles of 105° , 107° , and 109.5° . Explain.



7. (9 pts) The cyanate ion, NCO^- , has three possible Lewis structures.

(a) Draw these three Lewis structures, and assign formal charges to the atoms in each structure.

(b) What is the shape of the cyanate ion? Which Lewis structure is the preferred one? Why?

8. (12 pts.) Consider the following molecules: **PCl₅** , **PCl₃**. (i) Draw their Lewis structure, (ii) Determine the electron group and molecular geometries, (iii) Is the molecule polar or nonpolar?

(a) PCl₅

Electron Group Geometry: _____
Molecular Geometry: _____
Polar or Nonpolar?: _____

(b) PCl₃

Electron Group Geometry: _____
Molecular Geometry: _____
Polar or Nonpolar?: _____

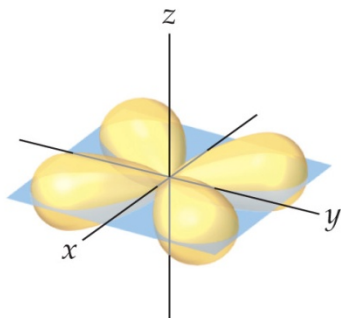
9. (6 pts) Using the periodic table as a reference, determine whether a bond between each of the following pairs of atoms is polar, nonpolar or ionic? Which is the most electronegative atom in each pair?

(a) N and F

(b) O and O

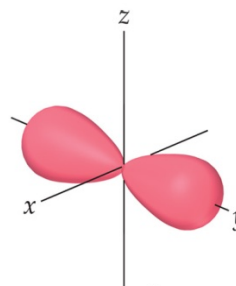
(c) Na and Cl

10. (i) (8 pts) **Identify** each of the following orbitals, and give the **n and l values** and the **orbital designation** (e.i. 4f).



(in fourth shell)

orbital: _____
 n= _____ l= _____
 designation: _____



(in fifth shell)

orbital: _____
 n= _____ l= _____
 designation: _____

- (ii) (2 pts) Tell whether the following combinations of quantum numbers are allowed or not allowed.

$n = 3, l = 3, m_l = -1$ _____

$n = 4, l = 2, m_s = 0$ _____

- (iii) (4 pts) What is the maximum number of electrons that can have of the following quantum numbers?

$n = 3, l = 2$ _____

$n = 4, l = 3, m_s = -\frac{1}{2}$ _____

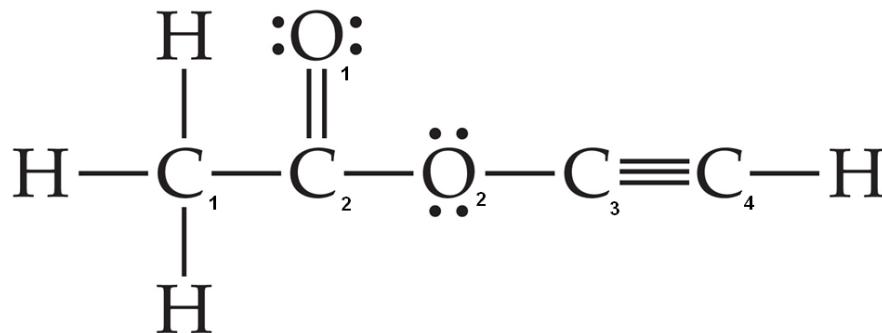
11. (i) (6 pts) Draw the **orbital diagram** of the atom with **atomic number 14** and show the number of valence electrons, core electrons and unpaired electrons.

(ii) (2 pts) Write the **full** electron configuration for Br^- .

(iii) (3pts) Arrange the following elements in order of **increasing** atomic radius: Cs, Ga, O, Al, C, K.

(iv) (3 pts) Arrange the following elements in order of **increasing** ionization energy: S, Rb, F, Ge, Ca.

12. (8 pts.) (a) What are the hybridizations of the **four carbon** atoms, the **two oxygen** atoms?



C₁: _____

O₁: _____

C₂: _____

O₂: _____

C₃: _____

C₄: _____

How many sigma bonds and pi bonds does the molecule have?

_____ sigma bonds

_____ pi bonds

- (c) (6 pts.) Draw the Lewis structure of the following and determine the hybridization of the central atom: XeF₄ and XeF₂. How many sigma bonds and pi bonds do the molecules have?

13. (17 pts.) Using the molecular orbital energy diagram given below (for **ALL** electrons):

a. (8 pts) Complete the molecular orbital energy-level diagram for O_2 and write its electron configuration. Label all the atomic orbitals and molecular orbitals. Sketch the shape of the σ_{1s} and σ_{1s}^* molecular orbitals.

b. (3 pts) Determine the bond order of O_2 . Is O_2 paramagnetic or diamagnetic? Why?

c. (6 pts.) If two electrons are removed from O_2 to form O_2^{2-} , how many unpaired electrons would O_2^{2-} have? Calculate the bond order of O_2^{2-} . Which would you expect to have a stronger bond, O_2 or O_2^{2-} ? Longer bond? Why?

Bonus: (2 pts)

Rank the following gases from least dense to most dense at 1 atm and 298K: Cl_2 , SO_2 , N_2O . Explain.

Equations, Constants and Conversion Factors

$$E = \frac{hc}{\lambda}$$

$$d = \frac{PM}{RT}$$

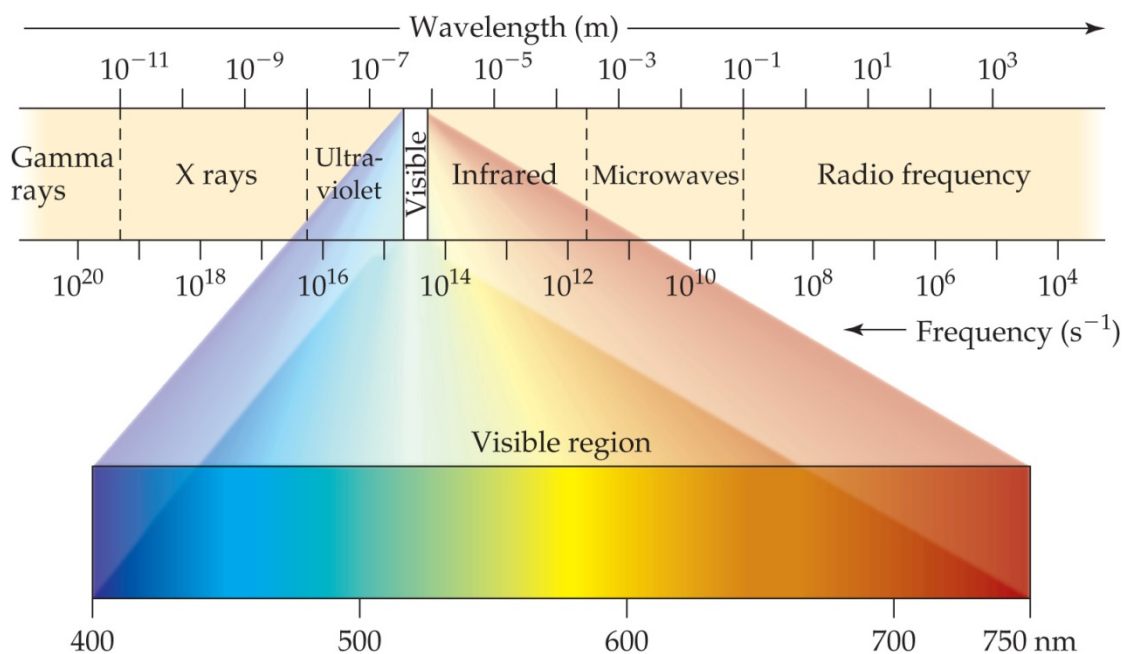
$$PV=nRT$$

$$1 \text{ nm} = 10^{-9} \text{ m}$$

$$h = 6.626 \times 10^{-34} \text{ J}\cdot\text{s}$$

$$c = 3.00 \times 10^8 \text{ m/s}$$

$$R = 0.0821 \text{ L}\cdot\text{atm}/(\text{mol}\cdot\text{K})$$



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